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Brookhaven Linac Isotope Producer

Facility Environmental Monitoring Report

Calendar Year 2002

BROOKHAVEN
NATIONAL LABORATORY

July 2, 2003

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GW63ER.03

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Summary of Results
During 2002, tritium concentrations in wells 40 feet downgradient of the BLIP target vessel did not exceed the 20,000 pCi/L drinking water standard, with a maximum detected concentration of 15,100 pCi/L in July. Continued monitoring of groundwater at a distance of 150 feet downgradient of the BLIP showed the remaining remnants of the slug of tritium released in 2000 by the VLB grout injection. The maximum tritium concentration observed at this distance was 44,100 pCi/L in April; it then steadily declined to less than the 20,000 pCi/L drinking water standard by June.

During CY 2002, the BLIP facility operated over a 21-week period. The major contributors to the emissions were carbon-11 and oxygen-15, with small amounts of tritium. The source release concentration for C-11 and O-15 were estimated to be 1.41E+03 curies, and 4.27 E+3 curie, respectively. These radioactive gases have very short half-life: 20.48 minutes for C-11 and 122 seconds for O-15, and mainly contribute to immersion external dose. The effective dose equivalent to the maximally exposed individual was calculated to be 0.086 mrem in a year.

Background

When the BLIP is operating, the Linear Accelerator (Linac) delivers a 200-MeV beam of protons that impinge on a series of eight targets within the BLIP target vessel. During irradiation, the BLIP targets are located at the bottom of a 30-foot underground tank, inside a water-filled 18-inch diameter shaft that runs the length of the tank. The targets are cooled by a 500-gallon closed-loop primary cooling system. During irradiation, several radionuclides are produced in the cooling water, and the soils immediately outside of the tank are activated due to the creation of secondary particles produced at the target. Air emissions from the BLIP facility pass through a HEPA filtration system. Following filtration, small quantities of oxygen-15 and tritium are released to the atmosphere.

In a 1985 redesign of the vessel, leak detection devices were installed and the open space between the water-filled shaft and the vessel's outer wall became a secondary containment system for the primary vessel. The BLIP target vessel system conforms to Suffolk County Article 12 requirements and is registered with the Suffolk County Department of Health Services (SCDHS). The BLIP facility also has a 500-gallon capacity underground storage tank for liquid radioactive waste (change-out water from the BLIP primary system). The waste tank and its associated piping system conform to Article 12 requirements and are registered with SCDHS.

In 1998, BNL conducted an extensive evaluation of groundwater quality near the BLIP facility. Tritium concentrations of 52,000 pCi/L and sodium-22 up to 151 pCi/L were detected in a temporary well installed approximately 50 feet downgradient of the BLIP target vessel. Elevated levels of tritium (11,400 pCi/L) and sodium-22 (38 pCi/L) were also detected in shallow groundwater samples collected from a temporary well that was installed 150 feet downgradient of the BLIP. Due to the activation of soils and the detection of tritium and sodium-22 in groundwater, the BLIP facility has been designated Area of Concern (AOC) 16K under the Environmental Restoration Program.

Starting in 1998, BNL improved the stormwater management program at the BLIP to prevent rainwater infiltration of the activated soils below the building. The BLIP building's roof drains were redirected away from the building, paved areas were resealed, and an extensive gunnite (cement) cap was installed on three sides of the building. In May–June 2000, BNL undertook additional protective measures by injecting a colloidal silica grout, referred to as a Viscous Liquid Barrier (VLB), into the activated soils. The grout reduces the permeability of the soils, thus further reducing the potential for rainwater to leach radionuclides out of the soil and into the groundwater.

Environmental Monitoring Program

As required by DOE Order 5400.1, BNL has established an environmental monitoring program at the BLIP facility to evaluate potential impacts to environmental quality from its operation, and to demonstrate compliance with DOE requirements and applicable federal, state, and local laws and regulations. This program is fully described in the *BNL Environmental Monitoring Plan* (BNL, 2000; BNL, 2002). The monitoring program components are summarized below. The locations of monitoring wells near the BLIP facility are shown in Figure 1.

Monitoring Results

Groundwater

Monitoring data collected from January 1999 to July 2000 indicated that the corrective actions taken during 1998 were highly effective in preventing the release of tritium and sodium-22 from the activated soils surrounding the BLIP target vessel. Prior to May 2000, tritium and sodium-22 concentrations in wells directly downgradient of BLIP were <3,000 pCi/L and <5 pCi/L, respectively. However, significant increases in tritium and sodium-22 concentrations were observed in groundwater samples collected after the VLB grout injection process in late May through early June 2000 (Figure 2). Samples collected in early July indicated tritium and sodium-22 concentrations of 5,700 pCi/L and 57 pCi/L, respectively. By early October, tritium concentrations increased to a maximum of 56,500 pCi/L in samples from monitoring well 064-67, located approximately 40 feet downgradient of the BLIP vessel. In accordance with the BNL Groundwater Protection Contingency Plan, BNL and DOE notified the regulatory agencies of this situation and increased the groundwater sampling frequency to bi-weekly. At the request of the

regulatory agencies, the well sampling frequency was increased to weekly starting December 1, 2000. The maximum sodium-22 concentration was 299 pCi/L, detected in well 064-67 on December 1, 2000. By December 21, 2000, tritium concentrations dropped to below the 20,000 pCi/L drinking water standard in wells located approximately 40 feet downgradient of the BLIP, and weekly sampling of the wells was discontinued by the end of January 2001.

During 2001–2002, tritium concentrations in wells located 40 feet downgradient of the BLIP did not exceed the 20,000 pCi/L standard (Figure 2). During 2002, the maximum tritium concentration was 15,100 pCi/L, detected in well 064-67. As the slug of tritium that had been released during the VLB grout project continued to migrate downgradient, tritium concentrations in well 064-50 increased and reached a maximum of 60,800 pCi/L in July 2001. During the remainder of 2001 and 2002, tritium concentrations in well 064-50 fluctuated. Concentrations declined to less than 20,000 pCi/L by November 2001, increased to a maximum of 44,100 pCi/L in April 2002, then steadily declined to less than 5,000 pCi/L by July 2002 (Figure 3).

Air Monitoring

Air emissions from the BLIP facility pass through a HEPA and charcoal filtration system before being released through a 16-meter stack. Air samples are collected after the HEPA and charcoal filtration system, to continuously monitor the emissions. Particulates are collected on a glass fiber filter for gamma analyses, and a TEDA-loaded charcoal cartridge is used for radioiodines. Tritiated water vapors are collected with silica gel. Radiological gases emissions, such as oxygen-15 and carbon-11, are estimated using an emission factor that is based on hours of operation and the beam intensity received on the targets (i.e., mCi/micro-ampere-hrs). Additionally, the radioactive gas emissions were characterized with an inline sampling and positron detection system. The short-lived gases concentrations measured by the NaI gamma detection system were used in estimating the source term to the environment and for dose calculations to members of the public.

During CY 2002, the BLIP facility operated over a 21-week period. The major contributors to the emissions were carbon-11 and oxygen-15, with small amounts of tritium. The average source term for C-11 was estimated at 1.41E+03 curies, and O-15 was estimated at 4.27 E+3 curies. Carbon-11 and O-15 have short half-lives of 20.48 minutes and 122 seconds, respectively, and mostly contribute to immersion external dose. The effective dose equivalent to the maximally exposed individual was calculated to be 0.086 mrem in a year. Tritiated vapor emissions for the calendar year 2002 were measured at 0.18 curies.

In CY 2002, further reductions in emissions to the ambient air were pursued as an objective for the BLIP facility. Moisture is the primary source of emissions (humidity from the hot cell's cooling water). Therefore, a shroud seal was installed to enclose components of the assembly, which includes the cooling water surface (a 16-in. diameter shaft), the transfer cases for the target holder, the chain drive assembly (with motor supports), and any other associated appurtenances. The shroud seal should result in a

significant decrease (about 28 percent) in gaseous emissions. When enough operational data have been collected, its efficiency will be assessed.

The facility Emissions were below DOE's derived concentration guide limits for the members of the public, and well below EPA's air dose limit of 10 mrem in a year. Therefore, it can be safely concluded that there was minimal impact to the environment and the public from BLIP operations.

Future Monitoring Actions

It is recommended that:

- Groundwater samples should continue to be collected quarterly during 2003. Samples should be analyzed primarily for tritium. Particular wells immediately downgradient of the BLIP should be periodically tested for sodium-22. If tritium concentrations are continually less than the 20,000 pCi/L drinking water standard by the end of 2003, consideration should be given to reducing the sampling frequency to semiannually, starting in 2004.
- The continuous monitoring for particulates, radioiodines, and tritium should be kept the same, that is, weekly collection and analysis of filters/silica gel along with timely verification and validation of the analysis results.
- Sampling and monitoring for the short-lived gases should be continued during the facility operation until the efficiency of the shroud has been thoroughly tested, and emissions verified. The Environmental Protection Agency will be notified of the test results and future actions taken to keep the effective dose equivalent to member of the public below 1 percent of the NESHAPs standard.

References

BNL, 2000. *Brookhaven National Laboratory, Environmental Monitoring Plan 2000* (March 31, 2000). BNL-52584.

BNL, 2002. *Brookhaven National Laboratory Environmental Monitoring Plan, CY 2002 Update (January 2002)*. BNL-52584 (Update).

Table 1. BLIP Facility Summary of Tritium and Sodium-22 Results, CY 2002. The first two wells listed are upgradient of the BLIP. Wells 64-47, 64-48, and 64-67 are approximately 40 feet downgradient, wells 64-49 and 64-50 are approximately 150 feet downgradient, and well 64-02 is approximately 450 feet downgradient of the BLIP.

Well	Radionuclide	01-22-02	04-15-02	05-14-02	06-17-02	07-11-02	08-14-02	09-09-02	10-10-02
		(pCi/L)							
64-46	Tritium	<319	<417	NS	NS	324 +/- 185	NS	NS	<347
	Sodium-22	NA	ND			NA			NA
54-61	Tritium	<319	NS	NS	NS	NS	NS	NS	<347
	Sodium-22	NA							NA
64-47	Tritium	<319	<417	NS	NS	<295	NS	NS	500 +/- 235
	Sodium-22	NA	7.2 +/- 1.6			NA			NA
64-48	Tritium	1,390 +/- 252	1,200 +/- 302	NS	NS	866 +/- 214	NS	NS	1,330 +/- 286
	Sodium-22	NA	6.7+/- 1.5			NA			NA
64-67	Tritium	6,590 +/- 409	429 +/- 262	NS	NS	11,700 +/- 514	15,100 +/- 604	10,600 +/- 515	6,360 +/- 475
	Sodium-22	NA	6.9 +/- 1.6			NA	NA	NA	NA
64-49	Tritium	NS	<417	NS	NS	<295	NS	NS	400 +/- 232
	Sodium-22		ND			NA			NA
64-50	Tritium	8,590 +/- 456	44,100 +/- 1,140	25,800 +/- 942	5,960 +/- 418	4,710 +/- 370	NS	NS	3,410 +/- 373
	Sodium-22	NA	80.4 +/- 6.8	NA	NA	NA			NA
64-02	Tritium	NS	NS	NS	NS	NS	NS	NS	NS
	Sodium-22								

Notes:
Drinking water standard for tritium = 20,000 pCi/L; for sodium-22 = 400 pCi/L.
NA = Not analyzed for this radionuclide.
ND = Radionuclide not detected.
NS = Well not sampled during this period.

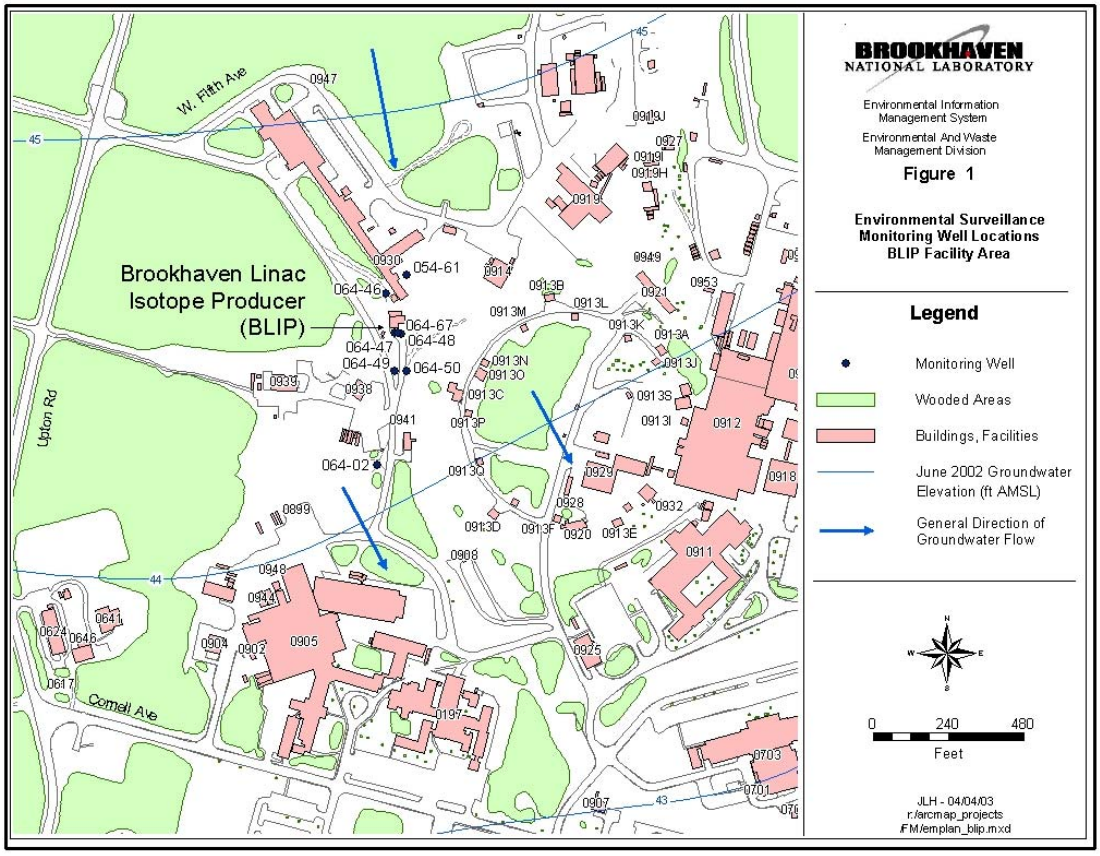

Figure 1. Monitoring Well Locations Near the BLIP Facility at BNL.

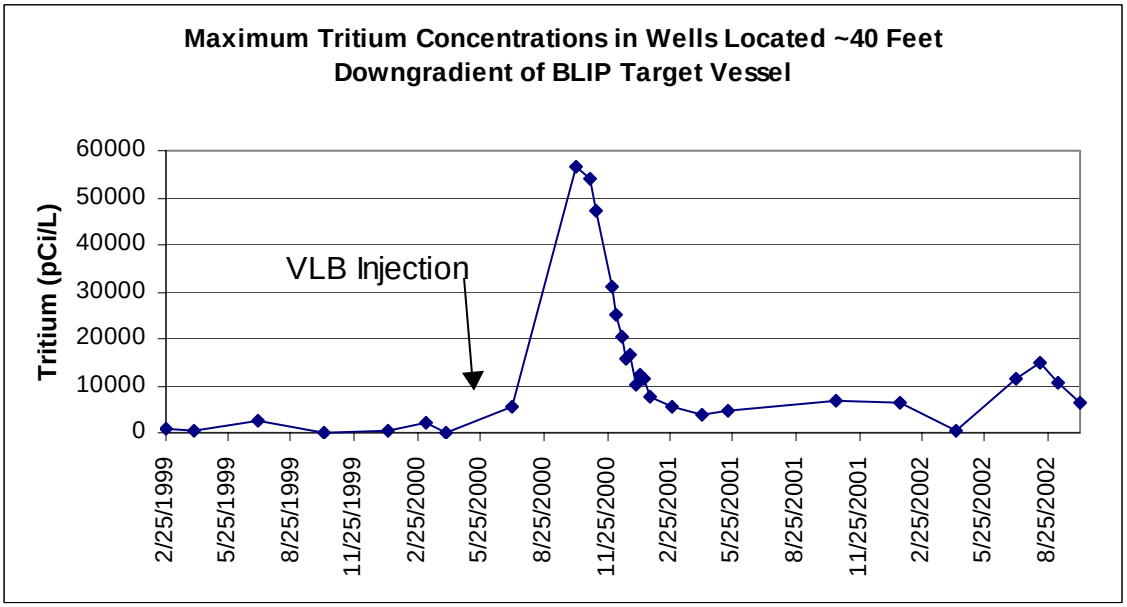

Figure 2. Tritium Concentration Trends 40 Feet Downgradient of the BLIP, CY 2000–2002.

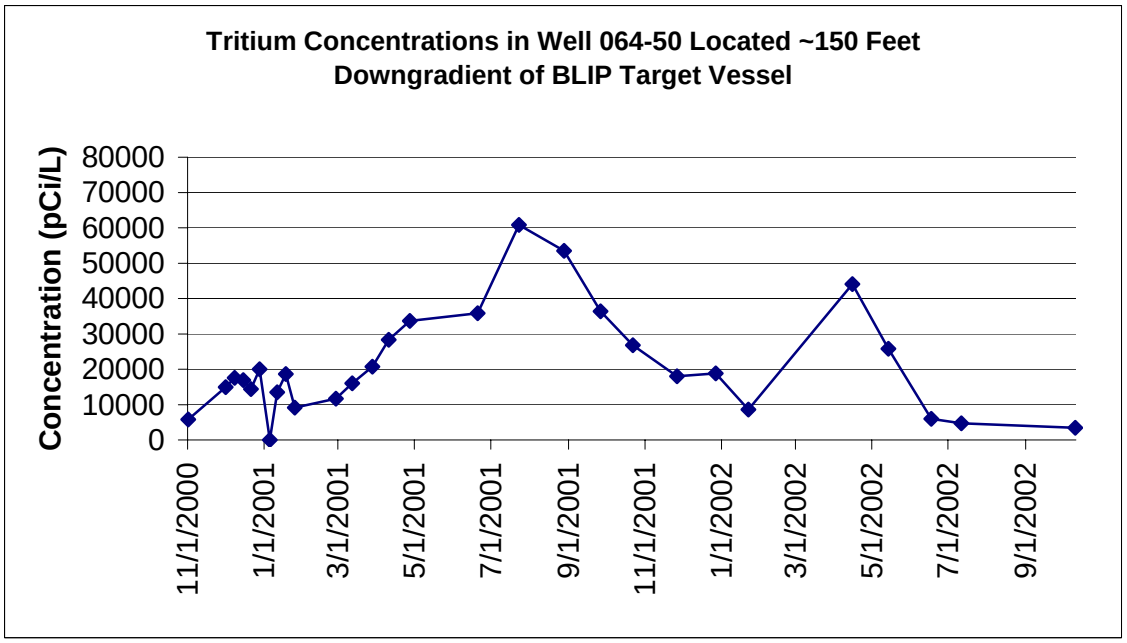

Figure 3. Tritium Concentration Trends 150 Feet Downgradient of the BLIP, CY 2000–2002.